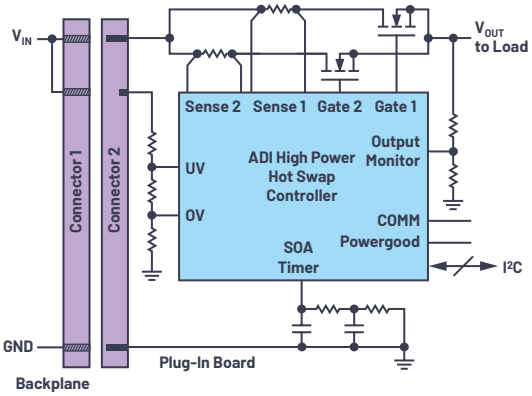
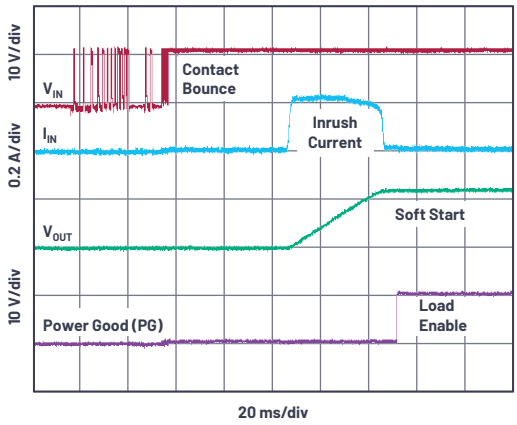
# High Power Hot Swap Controllers

- Dual Gate Drive
- SOA Timer
- Parallelable Controller
- FET-Bad Monitor




Analog Devices' hot swap (HS) controllers have enabled board insertion and removal from live uninterrupted systems for decades. However, today's power paths are quickly approaching kW levels of power, necessitating electronic protection that is more efficient and robust than ever before. In these mission-critical applications, basic HS controllers with a single gate drive have been used to drive parallel MOSFETs with low $R_{DS(ON)}$ and high safe operating area (SOA), resulting in unavoidably expensive solutions. To make things worse, MOSFET selection becomes more limited at higher current levels. Analog Devices' high power HS controllers employ multiple patented features that relieve MOSFET selection and costs, providing savings over traditional hot swap solutions while augmenting high power performance and reliability.

## Key Features:

- Enable safe board insertion and removal from live backplanes
- High voltage (-48 V to +80 V), high current operation
- Drive one or two MOSFET gates for high power applications
- Configurable single, parallel, or staged start MOSFET modes
- SOA timer to protect and optimize MOSFET usage
- Continuously monitor MOSFET health
- Parallel controllers for very high current levels
- I²C/SMBus telemetry or single-wire broadcast

| Decade | ADI Hot Swap Controller Innovation |
|---|---|
| 1990s | Single gate drive |
| 2000s | Telemetry |
| 2010s | Dual gate drive |

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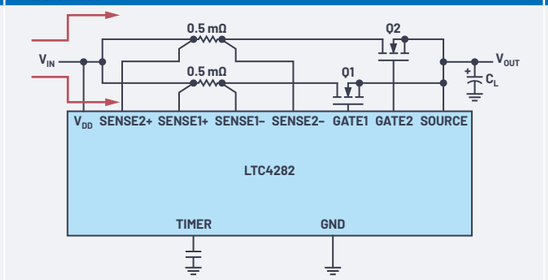
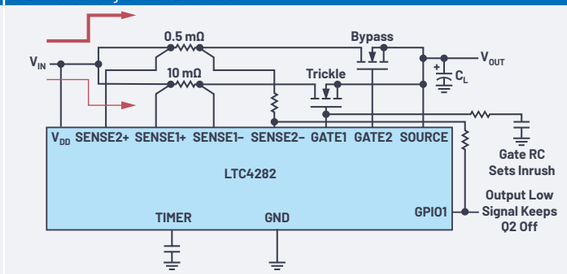
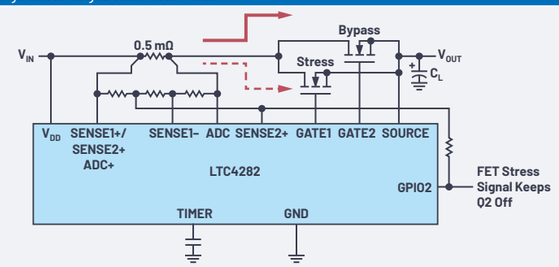
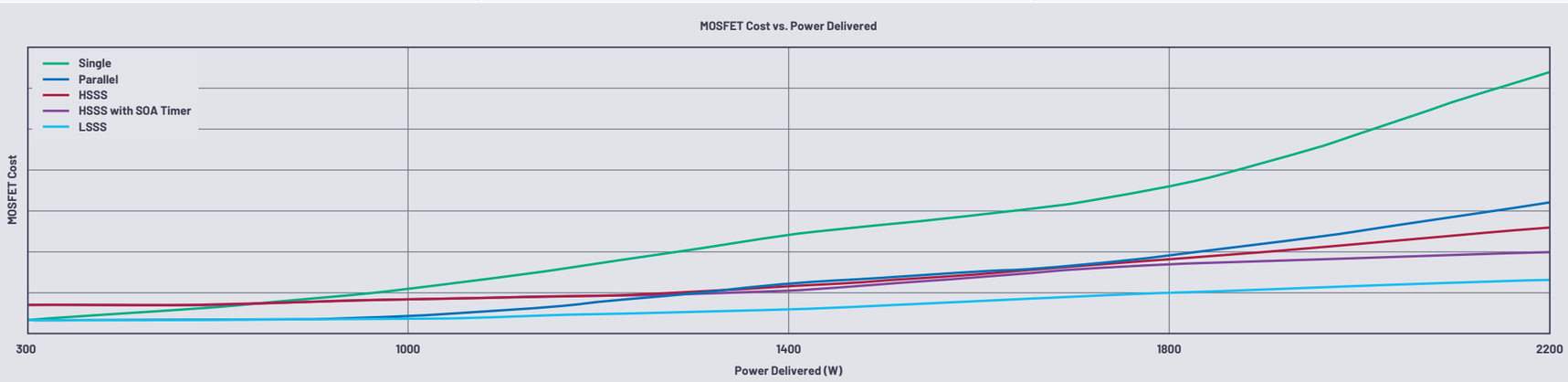
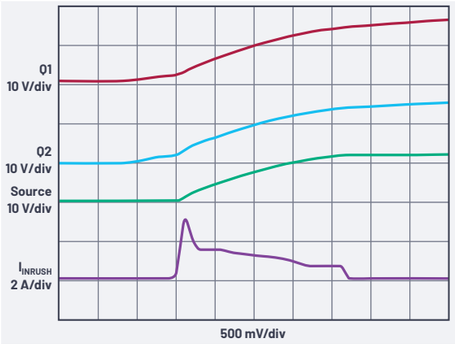
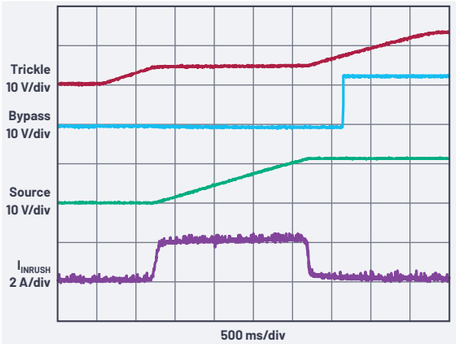
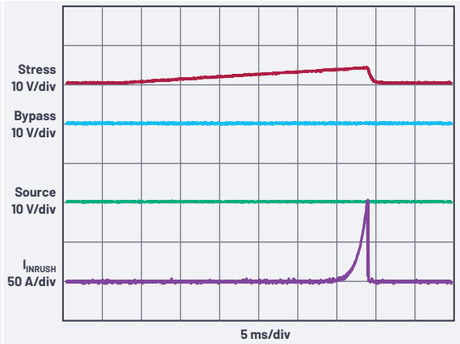
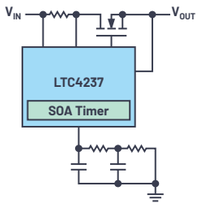
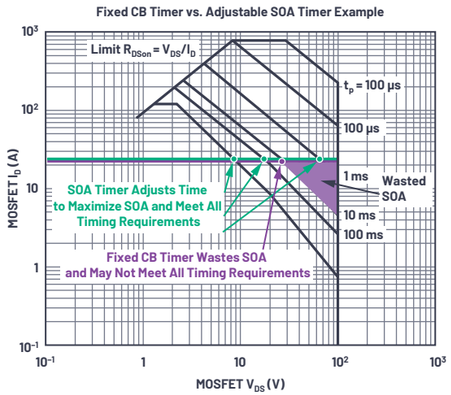
## Dual Gate Drive Operating Modes (Patented)

| | 1. Parallel Mode | 2. Low Stress Staged Start (LSSS) Mode | 3. High Stress Staged Start (HSSS) Mode |
|---|---|---|---|
| |  |  |  |
| Description | Load current is evenly divided between two identical MOSFETs or two groups of MOSFETs. During a stress event, both MOSFETs share stress until the timer expires. | A small fraction of load current flows through a trickle MOSFET during startup. After power is good, a bypass MOSFET turns on and carries the load. During a stress event, both MOSFETs immediately cut off system power. | Load current starts to flow through a stress MOSFET during startup. After power is good, the bypass MOSFET turns on and carries the load. During a stress event, the bypass MOSFET turns off and the stress MOSFET attempts to ride through the fault until the timer expires. |
| Benefits | Two gate drivers eliminate any possibility of one MOSFET taking on full transient stress due to gate threshold mismatch between two MOSFETs in a single gate drive solution. | | |
| | Lower MOSFET temperatures by up to 52% vs. a single gate drive solution. | Lower MOSFET temperatures by up to 53% vs. parallel mode. | Lower MOSFET temperatures by as much as 27% vs. parallel mode. |
| | Use smaller, cheaper MOSFETs with half the SOA or start up a load twice as big using the same MOSFETs vs. a single gate drive solution. | Lower MOSFET costs by up to 60% vs. parallel mode. | Lower MOSFET costs by up to 46% vs. parallel mode. |
| |  | | |
| Ideal Application | >800 W systems with large input steps or supply surges or starts into load (with SOA timer) | >1.5 kW systems with tightly regulated supply voltage (that is, no input steps or starts into resistive load) | >1.5 kW systems with input steps or supply surges or starts into load (with or without SOA timer) |
| MOSFET Requirements | Q1 = Q2 = medium SOA, medium $R_{DS(ON)}$ | Trickle = low SOA, $R_{DS(ON)}$ is a "don't care"<br>Bypass = low SOA, low $R_{DS(ON)}$ | Stress = high SOA, $R_{DS(ON)}$ is a "don't care"<br>Bypass = low SOA, low $R_{DS(ON)}$ |
| Start-Up Waveform |  |  |  |

## SOA Timer (Patented)

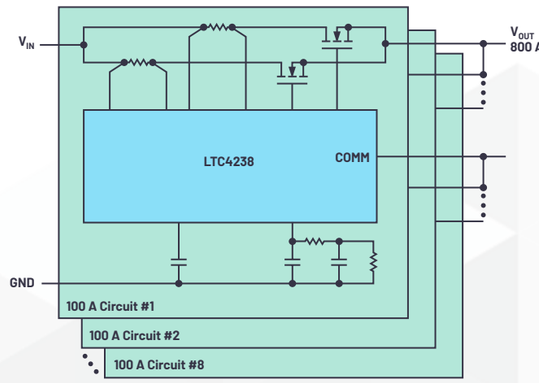
The SOA timer protects and optimizes MOSFET usage. Traditional hot swap controllers typically use a single external capacitor to set a fixed circuit breaker (CB) timer and ensure that a MOSFET operates within its SOA. This method prompts an expensive high SOA MOSFET to ride through the worst-case operating and fault conditions. Select ADI high power HS controllers also offer an SOA timer that uses an RC network to thermally model a MOSFET's SOA capability, enabling full SOA utilization and cheaper lower SOA MOSFETs than the fixed CB timer method would allow for the same set of conditions.



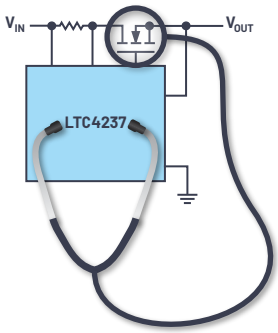

## Parallel Controllers (Patented)

Parallel controllers for very high load currents. Select ADI high power HS controllers with a COMM (communication) pin can be paralleled to coordinate turn on, turn off, and overcurrent faults between devices. Interchip communication includes making sure that all timers are held until each controller goes into their respective current limit. Mix and match controllers for flexible high power-expanding options!



## FET-Bad Monitor (Patented)

ADI's FET-bad monitor increases reliability and prevents catastrophic failure. Board debris can produce MOSFET leakage currents and gate shorts, potentially forcing a MOSFET to dissipate power beyond its capability and undetected when within the user-defined current limit (CL). As power levels increase, MOSFET failures become more prone to fires. Select ADI high power HS controllers can use the FET-bad monitor to continuously monitor the integrity of key MOSFET voltages, $V_{GATE}$ and $V_{DS}$. Then, if any faults are detected, MOSFETs are quickly turned off and may automatically retry connection when conditions are safe.




- Low $V_{GATE}$ detection
- High $V_{DS}$ detection

## High Power Hot Swap Controller Family

| Part Number | $V_{IN}$ Operating Range (V) | Gate Drive | SOA Timer | Parallelable | FET-Bad Monitor | Telemetry | Max Operating Temp (°C) | Package (mm) |
|---|---|---|---|---|---|---|---|---|
| LTC4281 | 2.9 to 33 | Single | | | • | | –40 to +85 | 4 × 5, 25-lead QFN |
| LTC4282 | 2.9 to 33 | Dual | | | • | | –40 to +85 | 5 × 5, 32-lead QFN |
| LTC4283 | –9 to >–80 | Single | • | | • | • | –40 to +125 | 5 × 7, 38-lead QFN |
| LTC4284 | –9 to >–80 | Dual | • | | • | • | –40 to +125 | 5 × 8, 44-lead QFN |
| LTC4237 | 6.5 to 80 | Single | • | • | • | | –40 to +125 | 4 × 5, 20-lead QFN, 20-lead SSOP |
| LTC4238 | 6.5 to 80 | Dual | • | • | • | | –40 to +125 | 4 × 5, 24-lead QFN, 24-lead SSOP |

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